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# SOURCE ROCK AND DOM EVALUATION WELL 1/6-1, NORWAY

by

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Investigation

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CONTENTS




KEYWORDS

Source rock, Carbonization, DOM, well 1/6-1, Norway

## I. INTRODUCTION

Geochemical investigations have been carried out on a suite of samples from the well as mentioned on the title page.

These investigations have been carried out to evaluate the presence and quality of source-rock layers, to establish the DOM trend and indicate the zone of possible oil and/or gas generation at the location of the well.

## II. EVALUATION OF SOURCE-ROCK PROPERTIES

### a. Source-rock indications

These indications have been determined by pyrolysis-sniffing[1] of the original samples. Moderate to high indications may indicate genuine source-rock properties or migrated oil or may be due to the presence of contaminants such as diesel oil used in the drilling fluid. To distinguish between the first possibility and the latter two, original samples with strong indications are remeasured after extraction with chloroform. Intervals or samples with high indications after extraction are investigated microscopically to ensure that the high values indicate genuine source-rock properties and are not due to contaminants insoluble in chloroform (such as walnut shells or other lost circulation material of an organic nature).

The results are given in the geochemical log (enclosure 1). For the location of the well see figure 1.

### b. Type of organic matter

The type of organic matter present in the samples was determined by pyrolysis/gas solid chromatography[2,3]. This is an empirical method in which the organic matter is ranked on the basis of its hydrogen content. The hydrogen content is lowest for organic matter of humic type and increases in order of the types: mainly humic, mixture, mainly kerogenous and kerogenous. Organic matter of humic type is a precursor of gas. Organic matter of mainly humic

type is also a precursor of gas; if sufficient quantities are present it may also yield oil. Organic matter of mixed type is a precursor of light oil (usually of a paraffinic nature) and gas. Organic matter of mainly kerogenous and kerogenous types are precursors of oil and gas.

The results have been included in the geochemical log.

## III. DEGREE OF ORGANIC METAMORPHISM

### a. Results

DOM values have been determined by measurement of vitrinite relfectance[4].

The results are plotted as a function of depth in figure 2 in the form of DOM histograms. Any histogram that could not be accommodated on figure 2 is given in subsequent figures.

In general, the mode value of the histogram may or may not represent the true DOM of the stratum from which the sample is taken. The DOM obtained from cuttings may have been influenced by vitrite from cavings. Alternatively, the DOM may refer to reworked, resedimented or allochthonous vitrinite. However, it is probable that the DOM obtained for samples with histograms that have a rather sharp mode value does represent the true-layer DOM.

### b. Compatible DOM

The compatible DOM is that which is in accordance with the present subsurface temperature and age of the formation in question. Knowledge of the compatible DOM is required to indicate the zone of possible oil generation (so-called cooking pot).

The dashed line in figure 2 indicates the compatible DOM trend based on[5-6] the present subsurface temperature gradient as indicated in the last figure. The temperature gradient is based on BHTs measured during logging after applying the so-called Middle East correction[7]. If only a solid line is given in figure 2, the compatible DOM coincides with the true-layer DOM trend.

Rapidly buried Mesozoic sediments (generally those overlain by 5000 ft or more of Tertiary sediments) follow the DOM/subsurface temperature established for these sediments[8]. Other Mesozoic sediments[9] and Palaeozoic sediments have been assumed to reach a given DOM earlier than Tertiary sediments. For a difference in age of 100 million years between the mid-age of the Tertiary and the mid-age of the sediments in question, the latter have been assumed to reach a given DOM $10^0$F sooner than Tertiary sediments.

The compatible DOM values 60 and 75 indicate the limits of the zone in which oil generation may take place. Source rocks for oil located within these limits are expected to generate oil. The major gas generation takes place below the level indicated by the compatible DOM 75.

In those cases where it can be assumed that the strata are presently at their maximum depth of burial, the compatible DOM also indicates the predicted true-layer DOM.

c. True-layer DOM

The true-layer DOM is the DOM that a humic coal would have when subjected to the same burial/temperature history as the formation in question.

The solid line in figure 2 is considered to indicate the trend of the true-layer DOM. It is based on those DOM values that are believed to be reliable. In this connection it can be remarked[10] that the standard deviation in the DOM measurement, including the variability occurring in nature, is 4 DOM units. The shape of the line, that is the rate of DOM increase as a function of DOM, is based on accumulated experience.

If the area has been uplifted, in the sense that the strata were once at greater depth, or if they have been at higher temperature, the true-layer DOM is higher than the compatible DOM. Source rocks with a true-layer DOM between 60 and 75 are mature for oil. If these source rocks have been uplifted, the true-layer DOM is incompatible.

Mature source rocks for oil have generated oil when the relevant strata have dropped below the level of the compatible DOM 60. Mature source rocks for oil lying outside the interval between the compatible DOM 60 and 75 levels are not expected to generate oil at present.

## IV. DISCUSSION AND CONCLUSIONS

Interval 9610 - 10112 ft (Eocene/Paleocene) contains source rocks for oil.

Interval 13500 - 14920 ft (Cretaceous) contains source rocks for gas and some oil (wet gas/condensate).

The zone of oil generation or cooking pot at the location of well 1/6-1, as indicated by the level of the compatible DOM 60 and 75, is between 10500 ft and about 13800 ft.

The histograms obtained for the sample from 9986 ft and those from below 10000 ft which would indicate a high DOM for this interval are not based on vitrinite but on fusinite particles broken in the shape of vitrinite. It is considered that the dashed line given in figure 2b indicates also the true layer DOM in addition to the compatible DOM.

REFERENCES

1. Gutjahr, C.C.M. & Reiman, K., Methods for recognition of source rocks. RKGR.0027.70, May 1970 (EP-41602).

2. Gutjahr, C.C.M., Characterization of organic matter in sediments by means of pyrolytic gas ratios.
Shell Dev. Co. Houston, Techn. Progress Report EPS 68-67-P, June 1967.

3. Gutjahr, C.C.M. & Reiman, K., Pyrolytic gas ratios of organic matter at 550°C.
RKRS.0005.69, pp.1 - 3.

4. Kötter, K., Die mikroskopische Reflexionsmessung mit dem Photomultiplier und ihre Anwendung auf die Kohlenuntersuchung.
Brennst. Chemie 41 (1960), pp.263 - 272.

5. Reiman, K. & Blaser, R., DOM as a function of subsurface temperature.
RKRS.0009.71, pp.11 - 18.

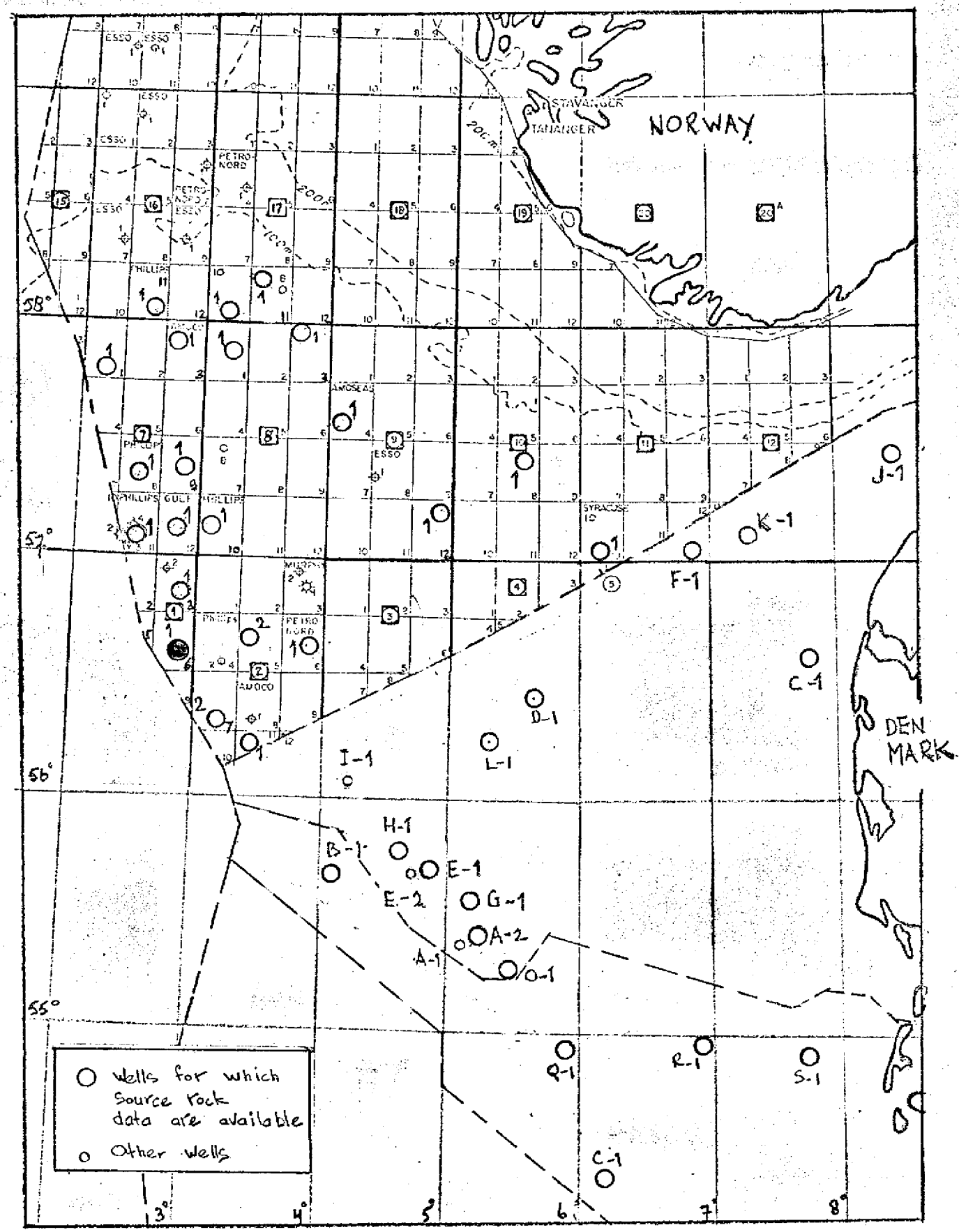
6. Reiman, K., On the prediction of DOM
RKGR.0093.72, October 1972 (EP-44101).

7. Habicht, J.K.A., Middle East temperature correction.
Middle East PEAC Book, vol.II.

8. Reiman, K., The DOM of rapidly buried Mesozoic sediments.
RKRS 0008.73, August 1973.

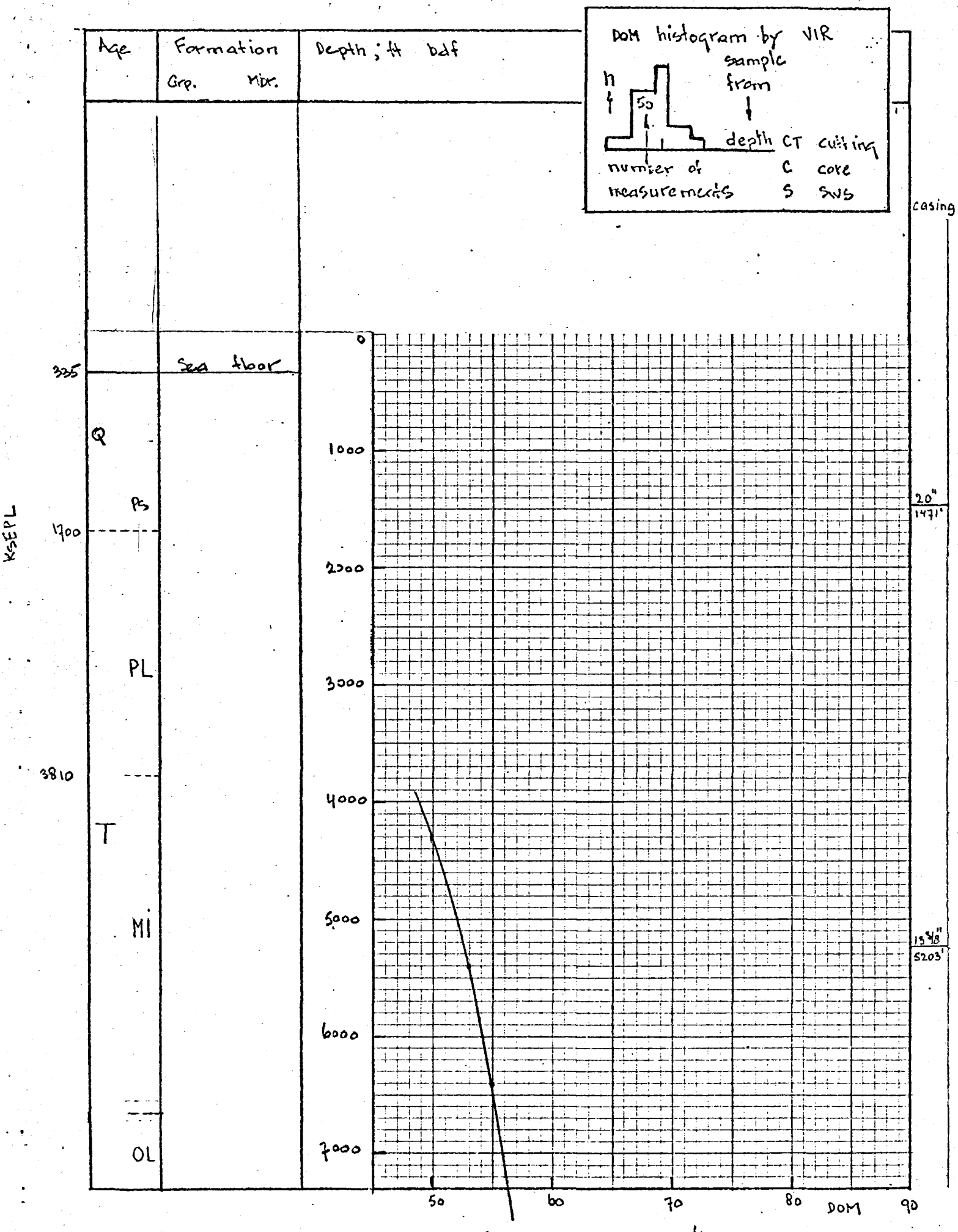
9. Reiman, K. & Leine, L., On the prediction of DOM for Mesozoic sediments, Perth Basin, Australia.
RKGR.0066.72, July 1972 (EP-43877).

10. Reiman, K. & Gutjahr, C.C.M., Vitrinite DOM values for pairs of humic sediments.
RKRS.0008.70, pp.21 - 23.



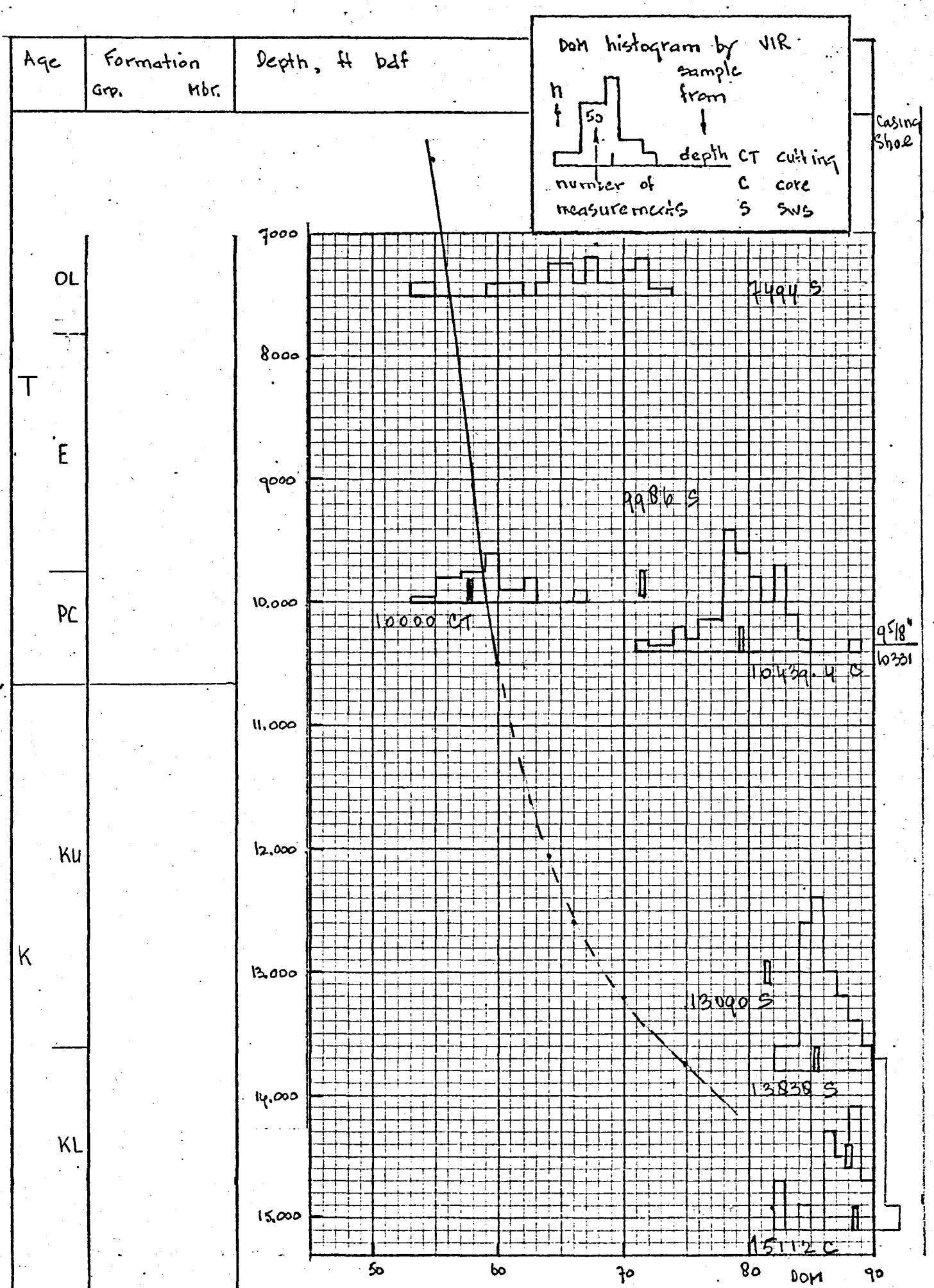

LOCATION MAP

Fig: 1




DOM AS A FUNCTION OF DEPTH, WELL - 16-1

FIG: 29




DOM AS A FUNCTION OF DEPTH, WELL 16-1

FIG: 2b

## DOM BY MEASUREMENT OF VITRINITE REFLECTANCE

Country: Norway

Well : 1/6-1

depth : 9986 Ft DOM: 71

Type of sample: ~~cuttings~~/SWS/~~core/surface/coal~~

The DOM of the sample is based on the mode value of the DOM histogram. It is [only] the DOM of the vitrinite mostly present in the sample. It may or may not coincide with the true layer DOM.

Number of measurements: 5 10 15 20 25 30 35 40 45 50

Analist : Abs

Relative reflectance [diamond = 100]

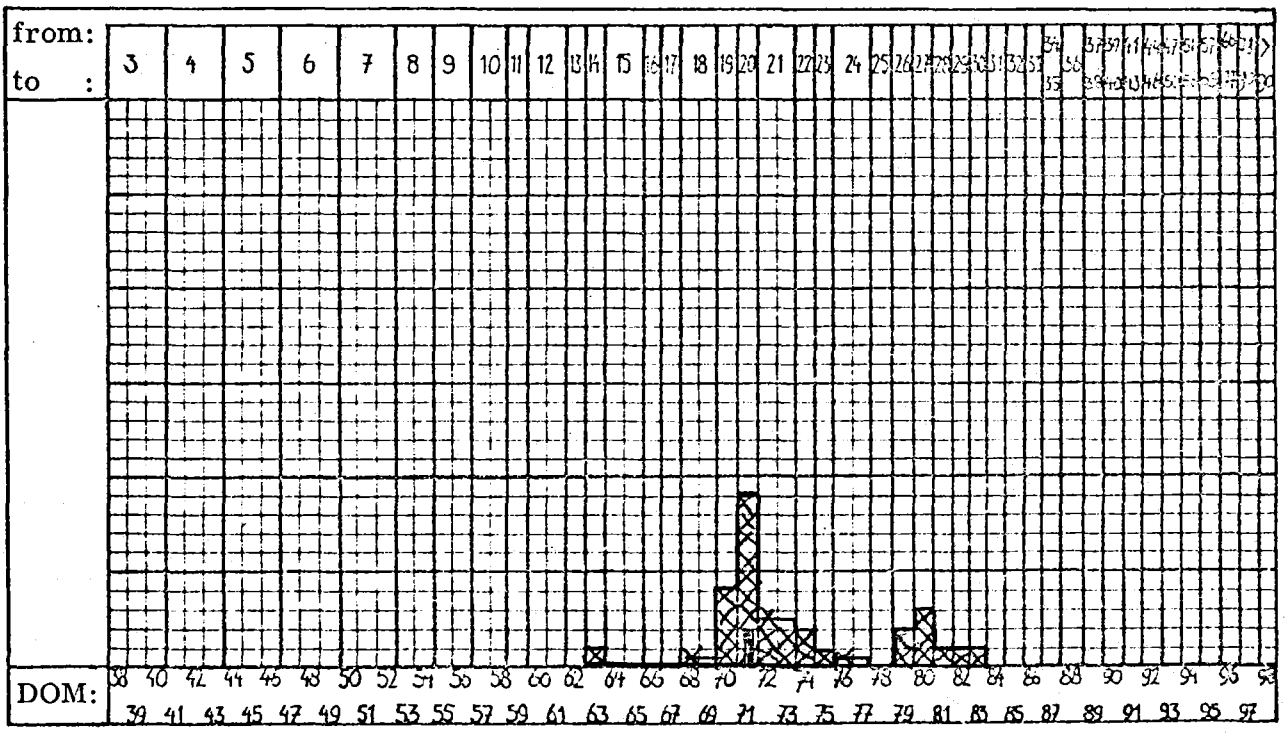



Fig. 3

## DOM BY MEASUREMENT OF VITRINITE REFLECTANCE

Country: Norway

Well : 1/6-1

depth : 13090 Ft. DOM: ~ 81 ?

Type of sample: ~~cuttings~~/SWS/~~core/surface/coal~~

The DOM of the sample is based on the mode value of the DOM histogram. It is [only] the DOM of the vitrinite mostly present in the sample. It may or may not coincide with the true layer DOM.

Number of measurements: 5 10 15 20 25 30 35 40 45 50

Analist : Abs

Relative reflectance [diamond = 100]

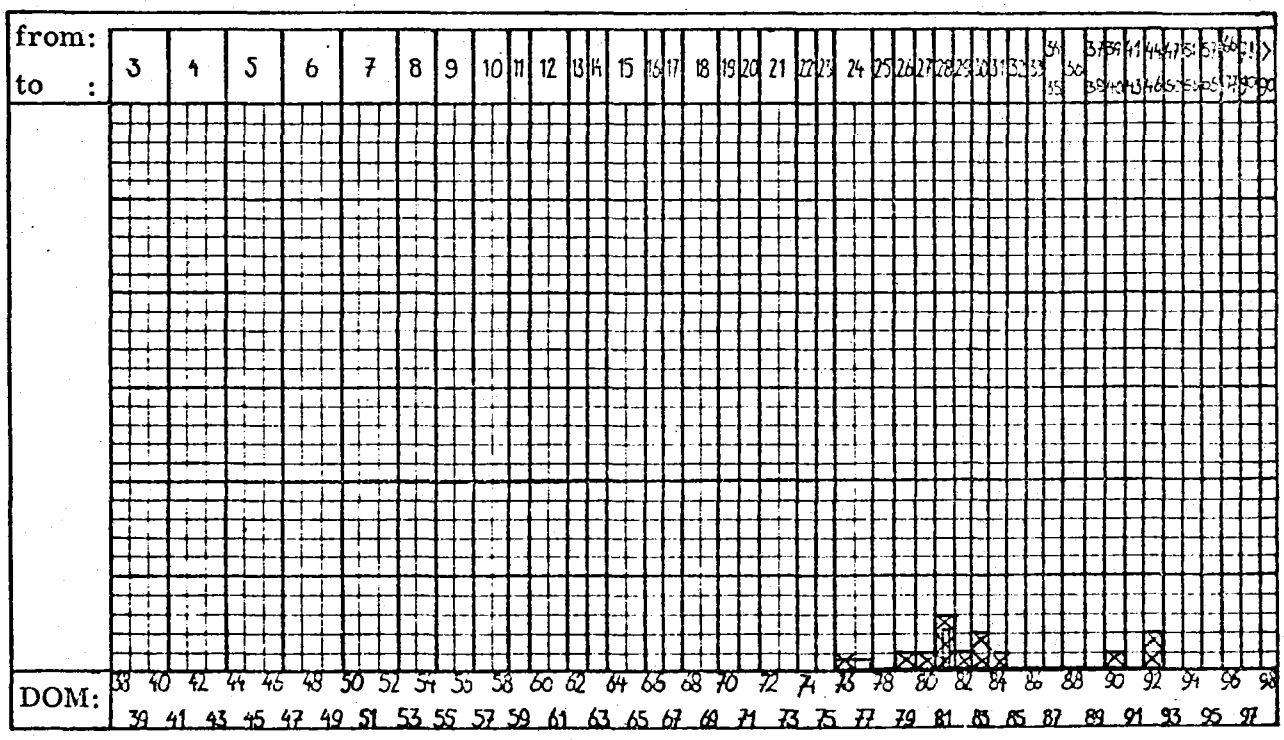



Fig. 4

## DOM BY MEASUREMENT OF VITRINITE REFLECTANCE

Country: Norway

Well : 1/6-1

depth : 14530 ft DOM: 88

Type of sample: cuttings ~~/SWS/core/surface/coal~~

The DOM of the sample is based on the mode value of the DOM histogram. It is [only] the DOM of the vitrinite mostly present in the sample. It may or may not coincide with the true layer DOM.

Number of measurements: 5 10 15 20 25 30 35 40 45 50

Analist : Abs

Relative reflectance [diamond = 100]

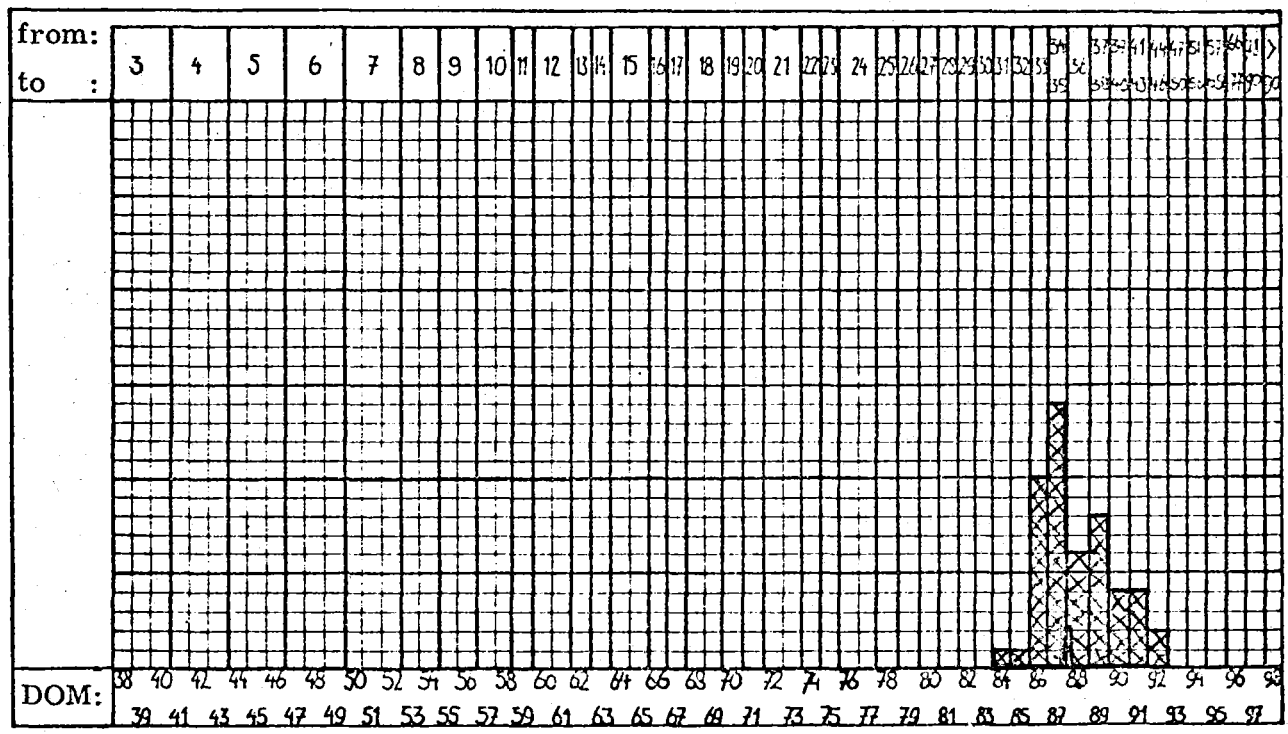



Fig. 5

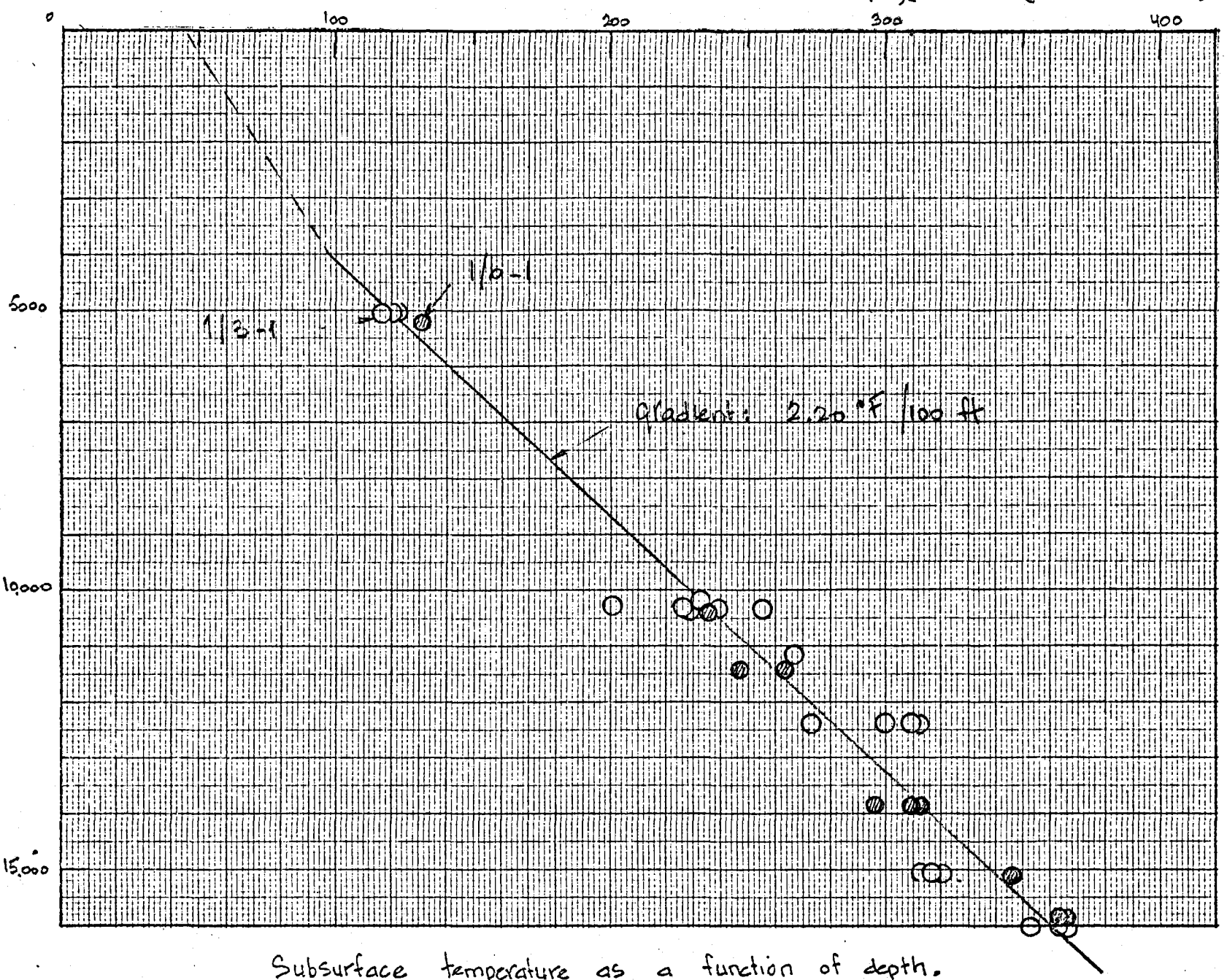



Fig 6

Subsurface temperature as a function of depth.
Wells 1/3-1, 1/6-1

FEET

REGEO-GEOCHEMICAL

Country: NORWAY



R101 00 1/6_1
R101 90 RKTR 0291.73 EP DATE: 731 OREIMAN/DIELWART

| | Depth bdf | Identifier 9 | Identifier 10 | Depth unit | | Source rock ind. | Type of organic matter | DOM Compatible | DOM True Uncons. |
|---|---|---|---|---|---|---|---|---|---|
| GC01 | N**** | N | N | Z | Z | N** | ZZ*N**Z | N* | N*Z |
| | 4000 | 0 | R | F | ? | | | 49 | 49 |
| | 6000 | 0 | | | | | | 54 | 54 |
| | 8000 | 0 | | | | | | 57 | 57 |
| | 11000 | 0 | | | | | | | |
| | 13000 | 0 | | | | | | 68 | |
| | 16000 | 0 | | | | | | | |
| | 18000 | 0 | | | | | | | |
| | 19500 | 0 | | | | | | 60 | 60 |
| | 12000 | 0 | | | | | | 64 | |
| | 13800 | 0 | | | | | | 75 | |
| | 7494 | 0 | | | | 0 | | | |
| | 9610 | 2 | | | | | | | |
| | 10112 | 1 | | | | 40 | M | | |
| | 10440 | 1 | | | | 0 | | | |
| | 13090 | 2 | | | | | | | |
| | 13500 | 1 | | | | 0 | | | |
| | 14920 | 1 | | | | 35 | MH | | |
| | 15112 | 1 | | | | 0 | | | |

This data sheet is added to facilitate those who wish to plot source rock and DOM information by computer. Information on the program is available from Central Offices, The Hague.

# GEOCHEMICAL LOG

SCALE 1:5000

WELL 1/6-1

| AGE | | FORMATION | DEPTH IN FT | LITHOLOGY | DOM | PYROLYSIS SNIFFING VALUE OF ORIGINAL SAMPLE 100 200 300 400 500 600 | PYROLYSIS SNIFFING VALUE OF SAMPLE AFTER EXTRACTION WITH CHLOROFORM 100 200 300 400 500 600 | DEPTH IN FT | ORGANIC CARBON %wt. | TYPE OF ORGANIC MATTER |
|---|---|---|---|---|---|---|---|---|---|---|
| | OL | | | | | | VALUES SMALLER THAN 30 ARE CONSIDERED NOT TO BE OF SIGNIFICANCE | | | |
| T | EO | | 7500 | | | | | 7500 | | MAINLY KEROGENOUS |
| | | | 8000 | | | | | 8000 | | |
| | | | 8500 | | | | | 8500 | | |
| | | | 9000 | | | | | 9000 | | |
| | | | 9500 | | | | TOP BASED ON GAMMA RAY | 9500 | | MAINLY KEROGENOUS |
| | PC | | 10000 | | | | INTERVAL 9610 _ 10112 FT CONTAINS SOURCE ROCKS FOR OIL | 10000 | | MIXTURE MIXTURE |
| | | | 10500 | | | | | 10500 | | |
| | | | 11000 | | | | | 11000 | | |
| | Ku | | 11500 | | | | | 11500 | | |
| K | | | 12000 | | | | | 12000 | | |
| | | | 12500 | | | | | 12500 | | |
| | | | 13000 | | | | | 13000 | | |
| | | | 13500 | | | | | 13500 | | HUMIC* |
| | KL | | 14000 | | | | INTERVAL 13500 _ 14920 FT CONTAINS SOURCE ROCKS FOR GAS AND SOME OIL. (WET GAS / CONDENSATE) | 14000 | | MIXTURE* |
| | | | 14500 | | | | | 14500 | | HUMIC* |
| | | | 15000 | T.D. 15818 Ft | | | | 15000 | | MAINLY HUMIC* HUMIC* |

* AS THE CARBONIZATION OF THE RELEVANT INTERVAL IS HIGH, THE TYPE OF ORGANIC MATTER MAY HAVE BEEN BETTER (AT LOW CARBONIZATION) THAN INDICATED.

Koninklijke/Shell
Exploratie en Produktie Laboratorium

GEOCHEMICAL LOG
OF
1/6-1
NORWAY

Author: DIW | Date: 10. 10. 73
Rep: RKTR 0291.73 | Encl: 1 | Draw.no: 1

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